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A longitudinal study on the effectiveness of the Research Experience for Undergraduates (REU) program at Missouri University of Science and Technology

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Longitudinal Study on the Effectiveness of the Additive Manufacturing Research Experience Evaluation for Undergraduates (REU) Program at Missouri University of Science and Technology

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ABSTRACT

The purpose of this study is to evaluate the Research Experience for Undergraduates (REU) program, sponsored by National Science Foundation (NSF), from 2011 to 2013. We examine the experiences of selected undergraduate students from across the country who came to Missouri S&T to participate in active art of researching; more specifically within the field of additive manufacturing. The student participants' experiences were monitored and evaluated through a set of qualitative and quantitative measures. Quantitative data for each year was gathered through a survey distributed at the beginning of the first week and at the end of the last week. Additional quantitative feedback was provided from either weekly or bi-weekly presentation evaluations. A follow-up survey was also conducted for all three years participants**.** Qualitative data was gathered through two semi-structured interviews, administered near the beginning and the end of the program in each year. Based on the results and analysis from gathered data, our evaluation indicates that the Missouri S&T Additive Manufacturing REU program improved each year and succeeded in its goals of increasing students' knowledge of the additive manufacturing processes. Our results also show improvement in the students' abilities to conduct individual research projects, work in an interdisciplinary environment, utilize computer-aided tools and laboratory facilities, and improving students' communication and presentation skills. Some limitations of the REU program are explained in the paper.

INTRODUCTION

Missouri University of Science and Technology (Missouri S&T) hosts an Additive Manufacturing Research Experience for Undergraduates program. Additive manufacturing, sometimes called direct digital manufacturing, is a class of manufacturing processes where by material is added in a layer-by-layer fashion to fabricate serviceable parts. This type of processing allows for the manufacturing of small to medium scale production and repair parts, which would be either impractical or impossible through standard manufacturing processes. Missouri S&T has multiple research labs dedicated to researching additive manufacturing processes, techniques, and materials.

The Research Experience for Undergraduates (REU) programs are summer research programs in the United States, sponsored by the National Science Foundation (NSF), and located in several universities. Students work closely with university faculty, staff, and graduate students to both further the understanding of a scientific field, and to participate in an academic research. Each year, selected undergraduate students come to Missouri S&T from across the country to participate in state-of-the-art research in the field of additive manufacturing. In the interests of both Missouri S&T and the NSF, student participants' experiences are monitored and evaluated through various qualitative and quantitative measures.

Missouri S&T REU program's purpose is to increase the students' knowledge of additive manufacturing, improve the students' ability to conduct an individual research project and integrate their research with that of others in an interdisciplinary team–based environment, improve the students' ability to utilize computer–aided tools in laboratory facilities, improve and increase the students' communication skills in a variety of media, and attract underrepresented students to participate in these activities. The evaluation process focuses on these points in addition to providing any relevant feedback pertaining to the program, especially feedback about how to improve the program.

PROJECT BACKGROUND

Additive manufacturing and its processes are unique for the engineering field in that they can construct almost any complex three-dimensional mechanical parts with its internal features in ways that are tool-less, minimize scrap material, and have functionally graded material properties. Missouri S&T conducts a large amount of research on additive manufacturing materials and methodologies. Various labs focus on different additive manufacturing processes, including: solid freeform fabrication (compression molding), rapid freeze prototyping using freeze-form extrusion fabrication (FEF), and selective laser sintering (SLS) using laser metal deposition (LMD).

Missouri S&T Additive Manufacturing REU program for the past three years has been held during the summer for ten weeks. The REU program is a research program that combines analytics, computer aided design, and hands-on lab work. Students are given individual research projects in the fields of mechanical engineering, manufacturing engineering, and materials science and engineering. The individual projects are performed in a loosely team-based, interdisciplinary environment with a mentoring system that connects the undergraduate students with professors, research assistants, and graduate students. Weekly discussions with industry and faculty experts gave students information and insight on new technologies, research methods and ethics, graduate school, and technical help. Students were also given the opportunity to develop communication and presentation skills, teamwork abilities, individual and group project management skills, and leadership abilities. Weekly extracurricular activities, including industry field trips to Boeing Research and Technology in St. Louis, Steelville Manufacturing Co., Mo-

Sci, and Brewer Science allow students to observe and internalize real-world research and engineering applications. Social trips to regional caves, St. Louis Six Flags, and St. Louis Cardinals baseball games provided students the time to strengthen group bounds, relax, and be entertained.

PARTICIPANTS

Thirty-one undergraduate students from universities across the country were invited to Missouri S&T for the summer Additive Manufacturing REU program from 2011 to 2013 (10 undergraduate students - 2011, 10 undergraduate students - 2012, 11 undergraduate students - 2013). Of the thirty-one participants, fifteen were male and sixteen were female; all of whom were between the ages of eighteen to twenty-five. An overwhelming majority of the participants were Caucasian (at 80%); followed by an even percentage of participants from a Hispanic (10%) and Asian (10%) background. In regards to their majors, roughly half of the students were from mechanical engineering background (45%). Material science and engineering was the second most comprised major; with the remaining majors coming in close percentages with each other, including: aerospace engineering, chemical engineering, ceramic engineering, industrial engineering, and biomedical engineering.

While the students come from many different areas of the country, a fair number of Missouri S&T students also participated in the REU program. Seven of those Missouri S&T undergraduate students were already working on projects within the program. These students in particular were selected to help with and work on their existing projects. The student projects of each successive year can be found in ***Appendix A***.

The students chose their overall project on the first day of the program, after reviewing the abstracts and presentations of each project from the respective graduate student mentor, who were currently working on the project. Depending on the projects' scope, some students were grouped together based on interest as well as correlated field specialty. The graduate student mentors were responsible for providing guidance and support for the undergraduate student who were assigned to their individual projects. Each student and mentor worked under a specific professor who oversaw their project during the duration of their research term. Students were actively encouraged and engaged, by their mentors and professors, to work with each other, as well as to seek additional university staff and faculty to advance their research. Further feedback was provided through the students' bi-weekly presentations and reports on their project work. They also met weekly with their assigned professors for updates and reassessment of their individual project status. The undergraduate students worked both individually and interactively with their mentors as appropriated by the project scope. Throughout the REU program, both quantitative and qualitative methods were used to evaluate the participants' research experience.

RESEARCH METHODOLOGY

In order to evaluate the REU program effectiveness at Missouri S&T, we gathered quantitative and qualitative data sets through surveys, interviews, and student evaluation sheets from faculty and mentors. For, quantitative data two surveys were given during the first and last week of the program for each year. Additional quantitative feedback was provided from bi-weekly presentation evaluations. Qualitative data for each year was gathered through two semi-structured interviews were administered near the beginning and the end of the program. We also have followed up with the students throughout the workshop and interview results were collected from them and analyzed.

Quantitative Analysis

In order to attract underrepresented students to participate in REU programs, demographic data, including the number of students, was gathered to help improve the design of promotional materials.

The initial survey was given at the first week of the program. This survey gathered the students' demographic information, gauged their initial technical writing abilities, tabulated their technical writing difficulties, and measured their interest in science in a variety of categories at the start of the program. The demographic questions asked for gender, age range, ethnicity, the student's major, what year of study they were in at their university (freshman, sophomore, etc.), and the name of their university. An adapted set of Likert scale questions was created from Fraser's work on scientific interest (Fraser 1981) to quantify the students' interest in science.[1] Questions regarding technical communication skills were adopted from the work of Plumb and Spyridakis (1992).[2]

Between the first survey and second survey students participated in a technical communication workshop to improve their report writing abilities. The second survey was given during the last week of the program. Interest in science (Fraser 1981) and technical writing skills (Plumb and Spyridakis 1992).[2] were measured again using the same questions from the initial survey. In addition, Hall et al. had questions about learning outcomes that were adapted and used in this second survey (2006). Ten Likert scale questions were borrowed from Williams (2000) to assess the program's effectiveness.[3] Likert scale questions regarding mentor relationships were taken from Ragins' and Cotton's earlier work (1999).[4]

Qualitative Analysis

Semi-structured interviews were conducted twice during the program to better understand the students and their research. The interview questions concentrated on the students' project work assessment, group dynamics, motivations, and mentor relationships; in addition, follow-up questions were used for clarification or to gain further information on a given topic. Interviews were arranged with each student individually, and were digitally recorded for accurate transcriptions and evaluations.

RESEARCH RESULTS

Demographic Information

From 2011 to 2013, thirty-one undergraduate students, ranging from ages eighteen to twenty-five, participated in the REU program at Missouri S&T. For each of the three years, roughly half of the students were male (48.39%) and the other half were female (51.61%). 2013 marked a marginal increase of student participants between the three years. Interestingly enough, 2011's REU program had a direct even split of male to female ratio; whereas, 2012 and 2013 alternated on male-to-female ratio majority. Overall, Missouri S&T has remained consistent in the number of students that have participated in the REU program, and relatively gender-equal. However, in terms of ethnic diversity across all years, Caucasians made up the overwhelming majority of participants at around eighty-percent. Other minorities including, Hispanic and Asians, comprised the remaining participants.

When examining the students' majors for all the recorded years of the REU program at Missouri S&T, 2011's students had come from a variety of majors, all of which had a relatively even spread. The majority of 2011's REU students' major was Material Science and Engineering, with other students coming from industrial, aerospace, mechanical, and chemical engineering backgrounds. However, during 2012 and 2013, REU students' majors shifted greatly towards mechanical engineering backgrounds majors; especially in 2013, where over 70% of the students were mechanical engineers.

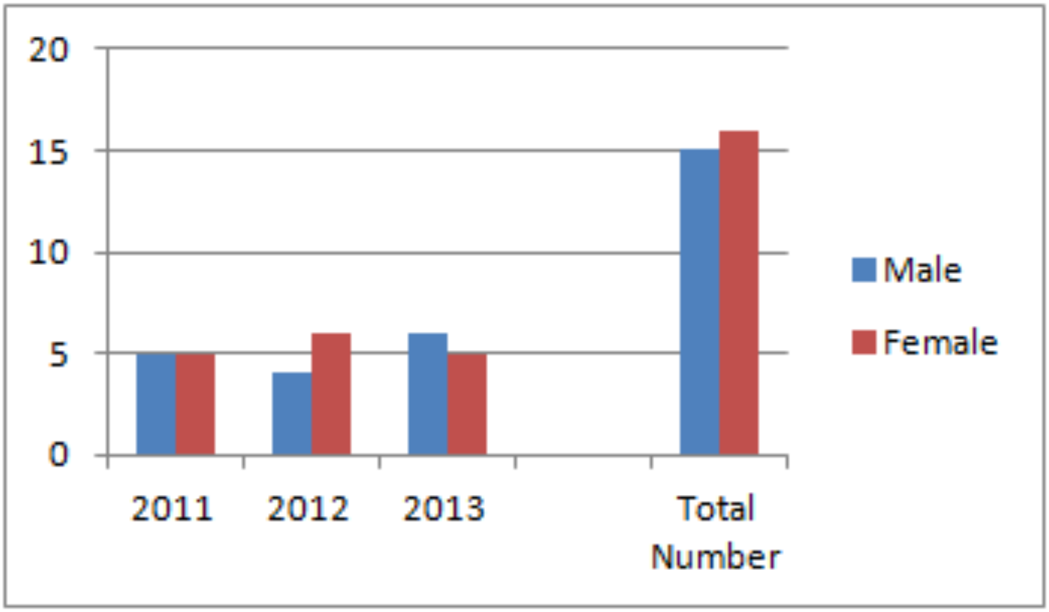

Figure 1: Gender Breakdown: (Across all years)

From 2011 to 2013 in **Figure 1**, thirty-one students have participated in the REU program at Missouri S&T. For each of the three years, about half of the students were male and the other half were female. 2013 marked a marginal increase of one student between the three years; additionally, exceeding 2012's higher margin of male compared to female. Overall, Missouri S&T has remained consistent in the number of students is has participating in the REU program, and relatively gender-equal.

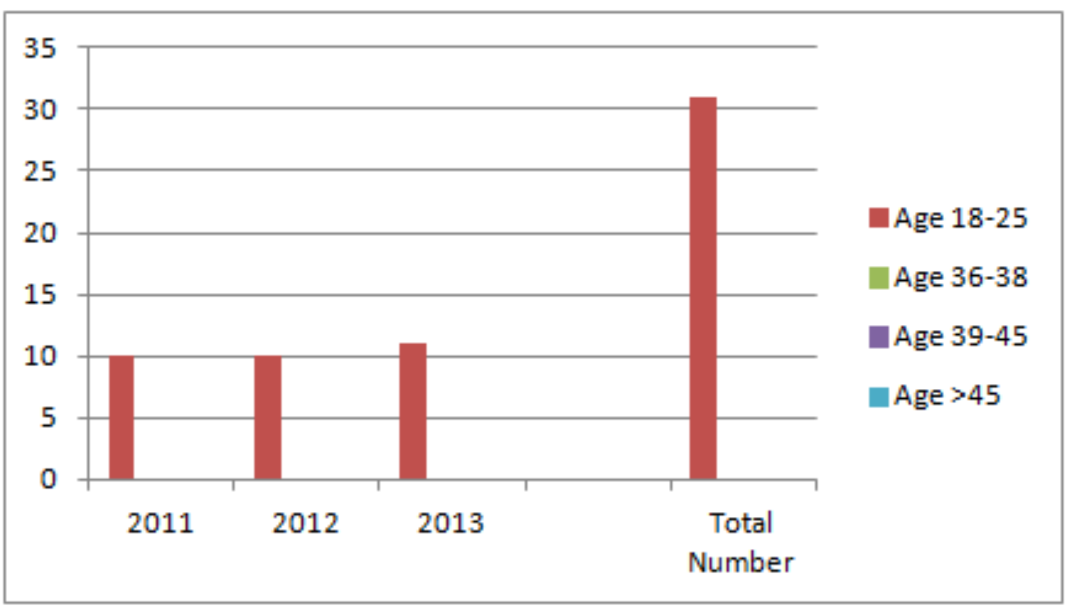

Figure 2: Age Breakdown (Individual and Across All Years)

In ***Figure 2***All of the students who participated in the REU program at Missouri S&T were undergraduate students whose age ranged from eighteen to twenty-five.

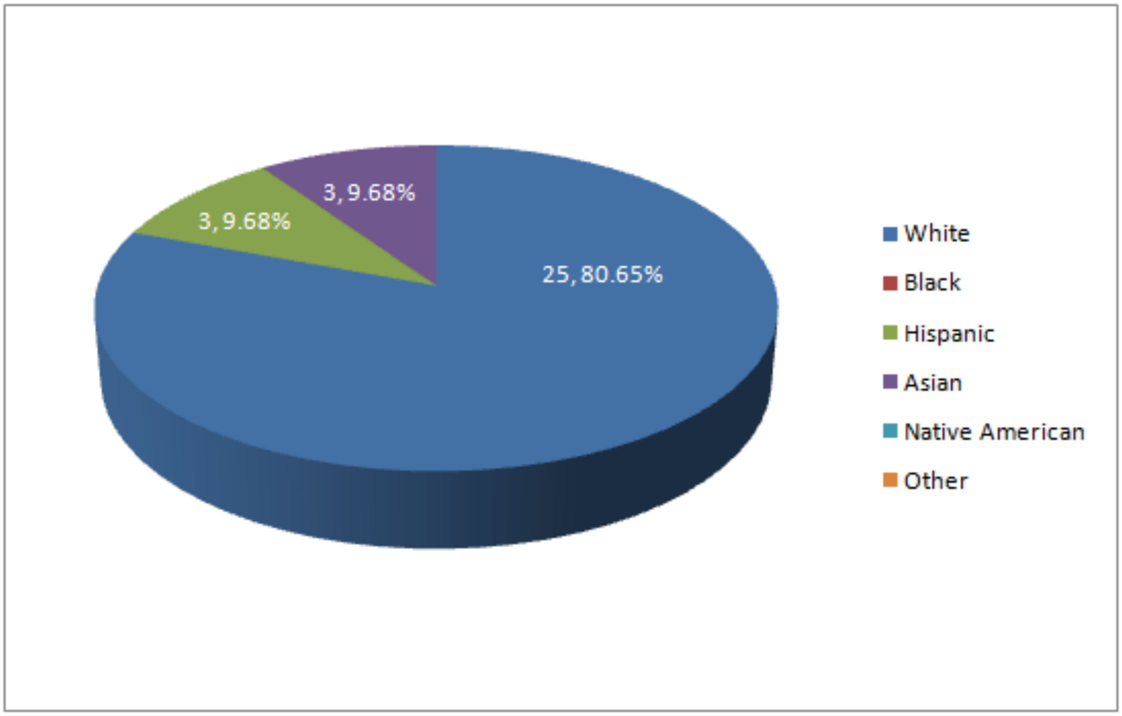

***Figure 3*: Ethnicity Breakdown (Across All Years)

From 2011 to 2013 in ***Figure 3***, the ethnic diversity for the REU program has been minimal. The overwhelming majority of the students involved were Caucasian (at 80%), with Hispanic and Asian who composed the remaining 20%.

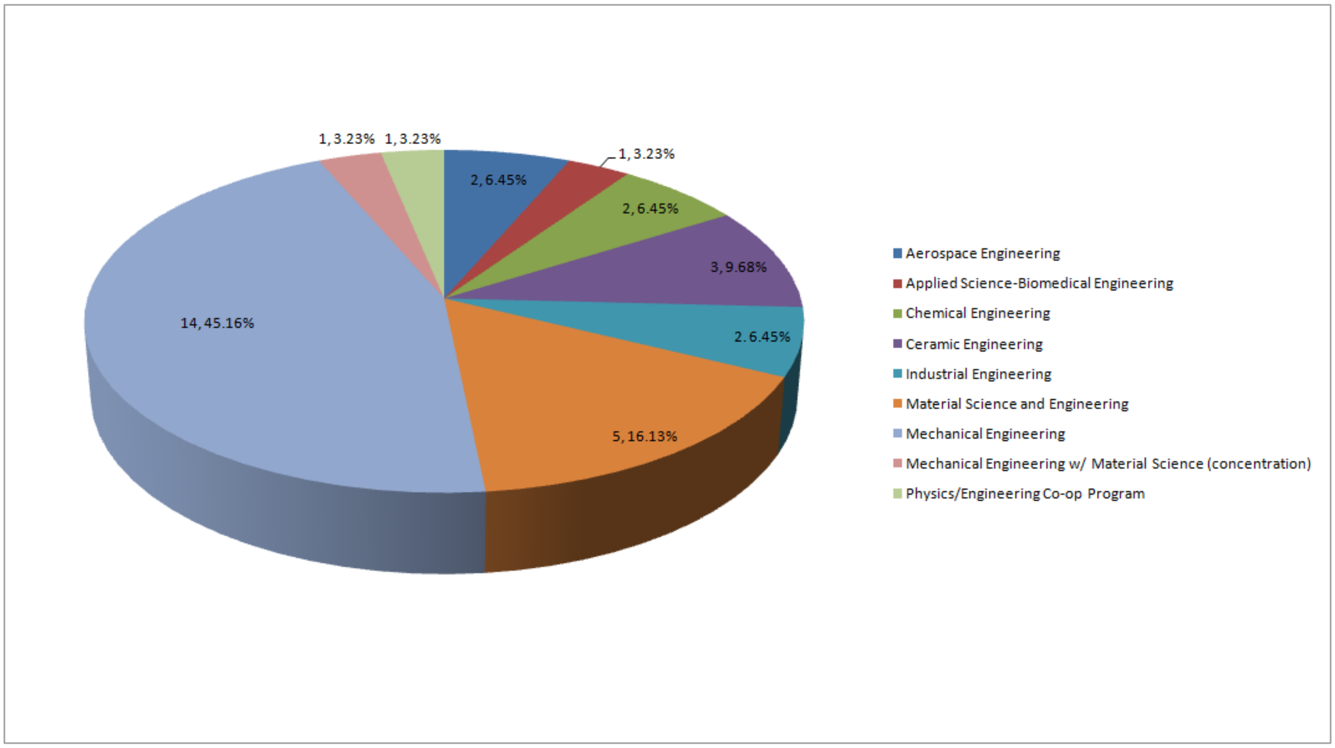

Figure 4: Major Breakdown (Across All Years)

For the REU program in ***Figure 4***, 2011 had a widespread variety of majors that the students had come from. The majority of 2011's REU students' major was Material Science and Engineering, with other students coming from industrial, aerospace, mechanical, and chemical engineering backgrounds. However, the 2012 and 2013's participating REU students increased tremendously with Mechanical Engineering majors; especially in 2013, where over 70% of the students were mechanical engineers.

Interest in Science

Likert scale questions were used to measure the students' interest in science, and were based on a scale of 1-7. One represented "Strongly Disagree" and seven represented "Strongly Agree". Lower numbers indicated a negative view towards science; whereas, higher numbers indicated a positive view towards science.

The students were asked a list of questions from three categories to measure their interest in science: general interest, career interest, and enjoyment which listed in ***Appendix B***. All the students displayed some positive levels interest in science both before and after the program, with their average median scores of 4.484, 4.584, and 4.954 in the three interests in science, respectively (general interest, career, interest, and enjoyment).

In the REU program's end survey, a second set of science interest questions were asked. These questions represented the attitudes of the participants by the end of the REU program. As stated before in the average interest in science scores by the students, they all had some level of positive interest in science from the general, career and enjoyment aspects in ***Figure 5***. However, 2012 is an odd year when in that their students' score was lower than those of 2011 and 2013. Despite that, the participants' interest in science across the three years had increased by the end of the program as opposed to the start of it. Since the program has different number of participants for each year and the participants were all different, we suppose to the numerical data slight change can be acceptable. In addition, by observing the trends across the years, interest in science, whether it be general, career, or enjoyment demonstrate an increment over the three years.

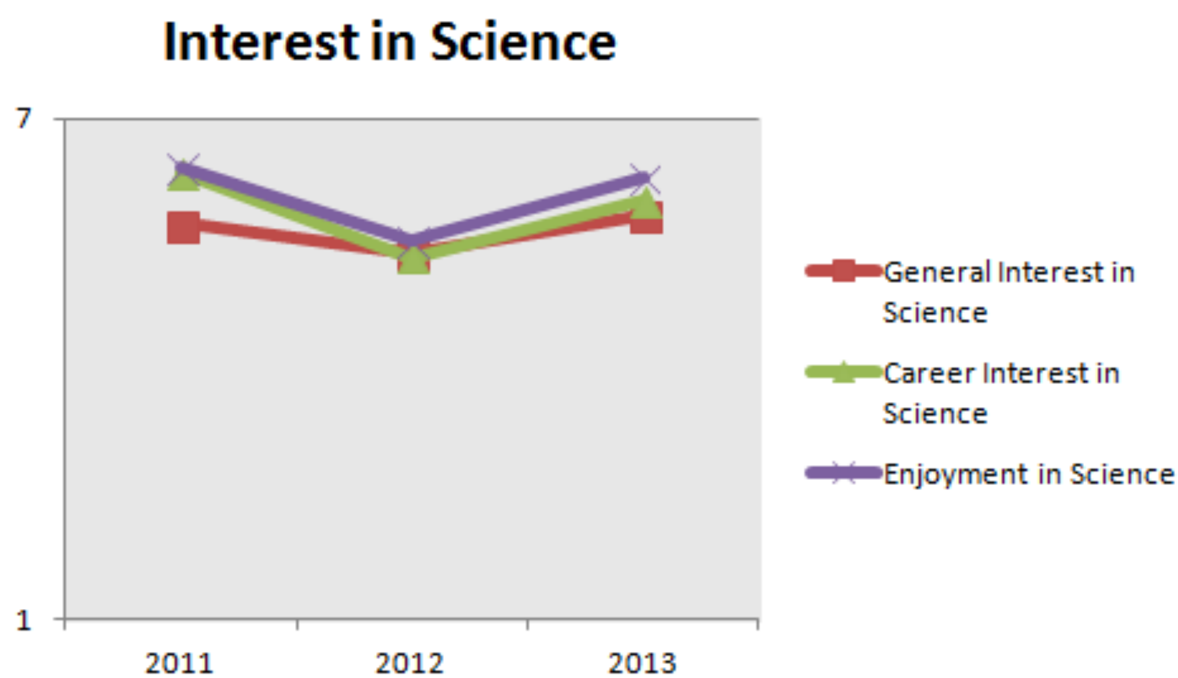

Figure 5: Interest in Science

Mentorship

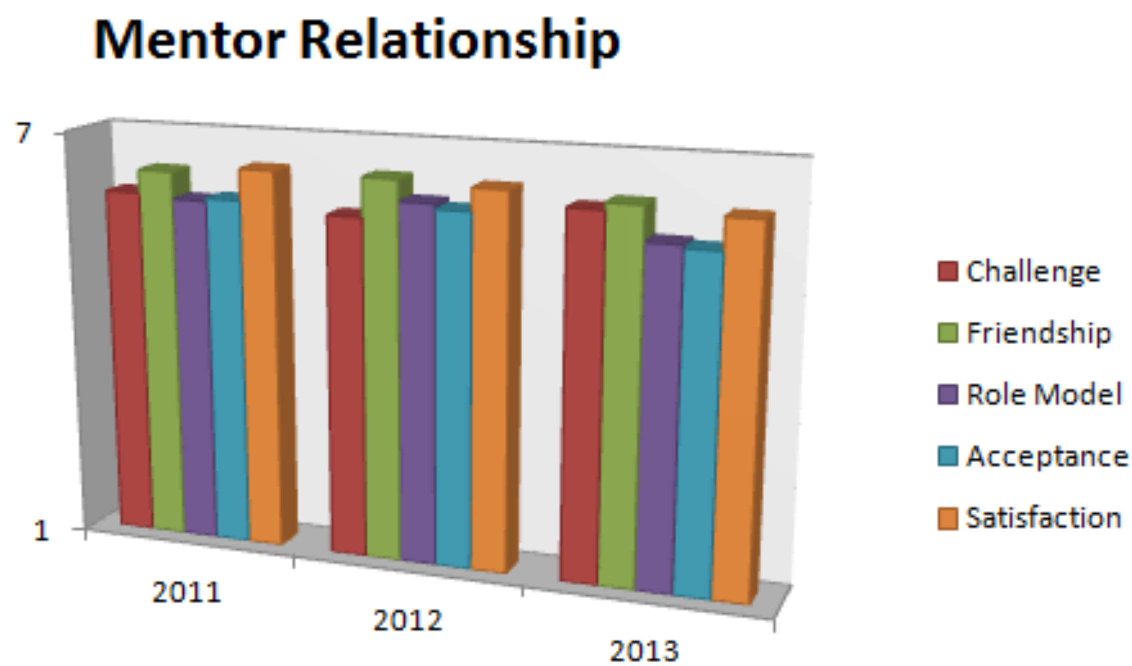

Figure 6: Mentor Relationship

Mentorship was broken into 5 sections composed of 16 total questions (See ***Appendix B***). The sections were challenges, friendship, role model, acceptance and satisfaction (with the mentor). All the questions again employed the same 7-point Likert scale, with 1 being the most negative and 7 being the most positive. We used the mean value of the participants' responses to represent the scores of each section in above chart.

Based off the results of the chart (See ***Figure 6***) and the mean value score, 2012 marked an improvement in the level of acceptance, role model rating, and friendship compared to 2011 - satisfaction remained the same. 2013 marks the lowest mean score when compared to prior years, and even had an increase in challenges in students working with their mentors. In interviews, 2013 students displayed frustration with organization and information detail in their projects for the REU program. This might explain why their scores are lower than compared to prior years.

Knowledge

To measure the REU students' knowledge, they had to answer 3 questions on the survey about their learning, motivation and real-world experience (See **Appendix B**). A 7 point Likert scale was used for answering and measuring the responses with one being the most negative response and 7 being the most positive response. The means for the participants' responses for learning, motivation and real-world engineering are measured by mean value of the participants' responses. In below graphic (See ***Figure*** *7*), the collective mean value for knowledge are between 5 (somewhat agree) and 6 (agree) which is positive from 2011 to 2013. However, 2013 marked a sharp decrease in motivation when compared to 2011-2012 mean values. Similar to mentorship, the lack of organization as mentioned by server students in 2013 is a potential cause for the decrease in value. Overall, the students' responses from the three years showed that the students believed they had learned more from the program, became more motivated by it, and felt their projects had some real-world significance and applicability.

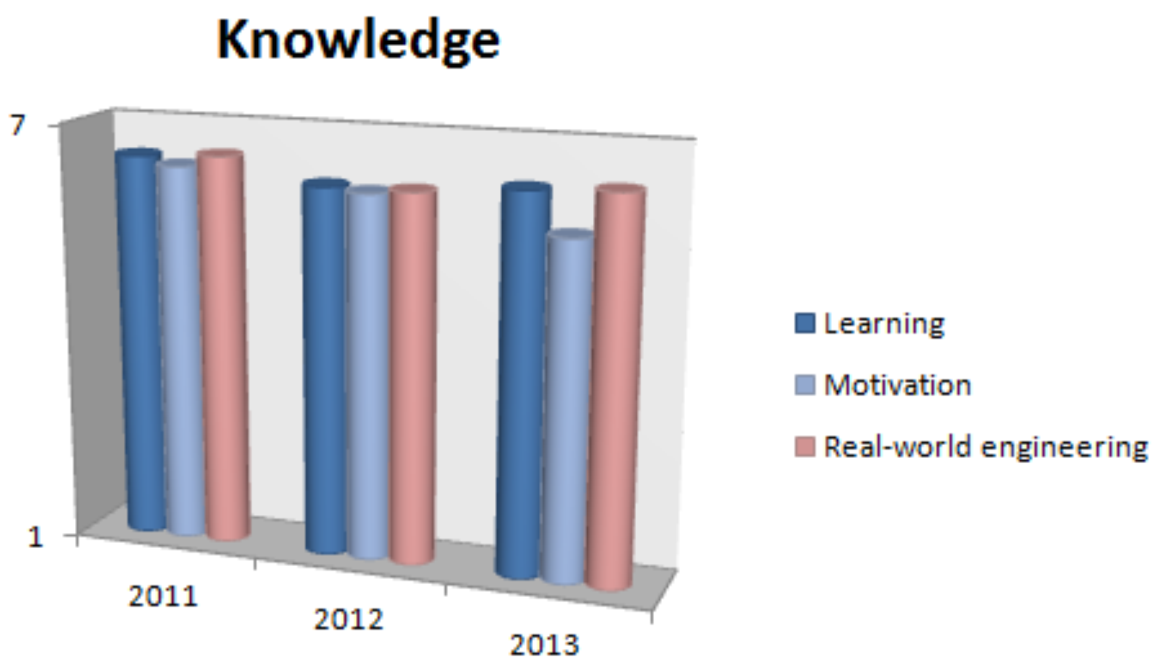

Figure *7*: Knowledge

Overall Assessment

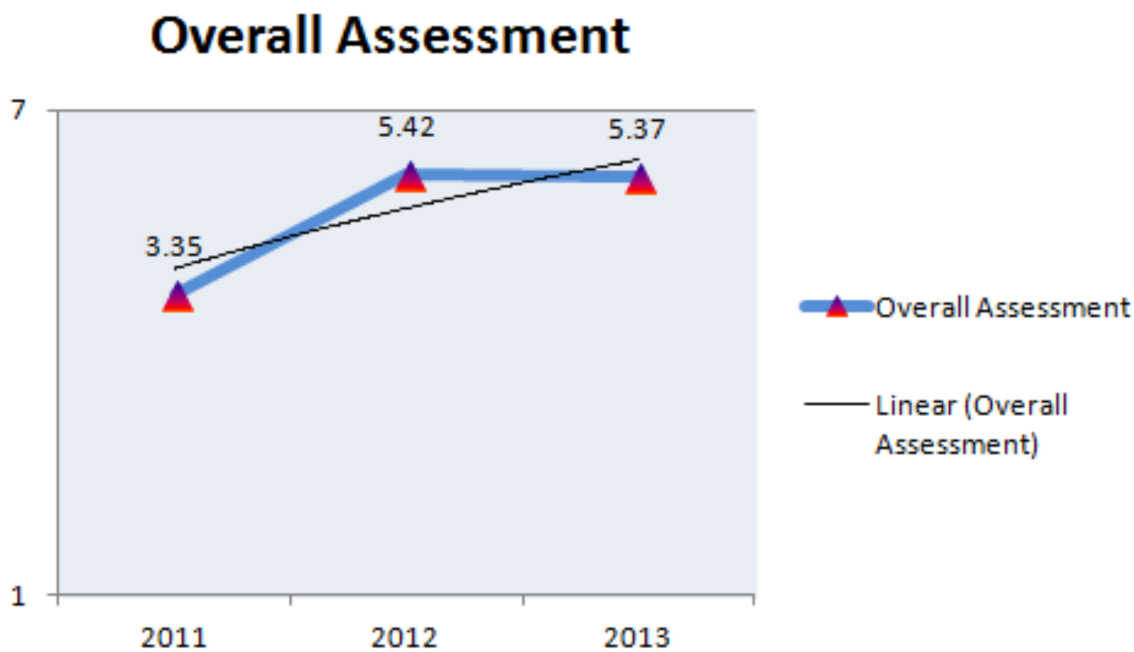

Figure 8: Overall Assessment

In the REU program's overall assessment section of the survey questionnaire, 10 questions (See ***Appendix B***) were asked and also measured by a 7-point Likert scale, with 1 being the most negative and 7 being most positive. The overall assessment's mean score initially started out as 3.35 in 2011 and increased to 5.38 by 2013. When observing average mean score of the overall assessment of the program by the student at 4.71 and looking at the trendline on the graph above (See ***Figure 8***), we see that not only is the average score higher than the starting year of the REU program but also that the linear line has a positive slope, indicating a positive trend or improvement of the students' attitudes and skill in their research experience.

Interview

The interviews were conducted twice during each year of the REU program at Missouri S&T. One interview was held near the start of the program, and another one was held near the program's end. The interviews were conducted for each individual with recordings for transcripts and audio referrals for later analysis. This helped to triangulate the quantitative results, and suggested that students in general were satisfied with their projects, mentors, team members, and workshop organizations.

The interview questions were designed to obtain more in-depth details of the students' REU camp experience. The purpose of the interviews was to learn more about the students' individual or group responsibilities for their project, their motivations, their social experience, their feelings on the REU program's structure and organization, and their learning experience in the program - both from the technical communication aspects and the engineering experience.

The interviews results of the students' experiences from the beginning of the program compared to the end reiterated the positive trends found from our analyses of the surveys and questionnaires. Most of the interviews were rather short as the students were unanimously happy with their co-workers, motivated to work, and satisfied with their work; though 2013's student expressed some concerns of meeting conflicts with their leading mentor professors. The students also each ended up having one particular professor or graduate student that functioned as their mentor. Our interview results demonstrated the students' dependence on their mentors at the beginning of the program was higher compared to their results in the end. This parallels the with survey results that indicated a higher level of knowledge and confidence the students had throughout their REU experience.

The students enjoyed and appreciated the opportunity that this REU project offered them, and they all felt they benefited from the technical communication workshops. The technical communication workshops were designed depend on what the students felt challenging part, for example: Brainstorming, Developing a rough draft, Writing a rough draft, Letting the rough draft rest before revising, Revising at several levels, Asking someone else to review your writing, Proofreading and so on. Most of them felt they benefited most from the presentation workshop. They were mostly satisfied with the bi-weekly report and presentation. Most offered suggestions for improvements or changes, particularly with the organization and structure of the program. Also, the increase in student participants in the REU program throughout the years matches the students' positive recommendations of the REU program. The students expressed that their motivations for their projects was facilitated by the pressures of presenting their projects, as opposed to their bi-weekly reports. Most felt a more detailed evaluation would be more helpful than ranking or scores but a few felt a more professional ranking would have given them perspective on how they were doing as compared to a real-world environment.

Communication was overwhelmingly conducted face to face via conversation in the labs but when they had difficulty getting an answer in the lab they would resort to e-mail and text messaging. As the camp progressed, most of the students became more at ease communicating with their mentors and professors.

The students all enjoyed the lab environment socially and structurally. The students unanimously felt they had made strong progress on their projects. Their presentations and conversation on their projects became much stronger over the course of the camp. Majority of the students said that they would recommend this workshop to others. We also identified some challenges students had during the workshop, which were mainly related to the organization of the workshop program's structure, such as clearly defining a set the goals to achieve and a timeline of it for their individual project; as well as giving clear instructions/direction to the students along the project.

CONCLUSION

Based on the quantitative and qualitative data gathered from the surveys, questionnaires, weekly, bi-weekly evaluations, and interviews, we conclude that this evaluation indicates that the Missouri S&T Additive Manufacturing REU program succeeded in its goals of increasing students' knowledge of additive manufacturing processes, improving students' abilities to conduct individual research projects, improving students' abilities to work in an interdisciplinary environment, improving students' abilities to utilize computer-aided tools and laboratory facilities, and improving students' communication skills. The issue of whether or not underrepresented students participated will be decided through a longitudinal study. It is safe to say that the program was a great success.

ACKNOWLEDGEMENTS

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APPENDIX

Appendix A:

2011: 8 Projects

No.	Project
1	Paste for Free-form Extrusion Fabrication
2	Fuel Cells and Membrane Electrode Assemblies
3	FAB@Home System
4	Heat Transfer Effects in Laser Metal Deposition
5	Free-form Extrusion Fabrication
6	Laser Metal Deposition
7	Corrosion Testing in Bipolar Plates in Fuel Cells
8	Laser Sintering of Bioactive Glass Bone Scaffolds

Of the eight projects, two students worked with paste for freeze-form extrusion fabrication, two worked with fuel cells and membrane electrode assemblies, one worked with the FAB@Home system, one worked with heat transfer effects in laser metal deposition, one worked with freeze-form extrusion fabrication, one worked with laser metal deposition, one worked with corrosion testing in bipolar plates in fuel cells, and one worked with laser sintering of bioactive glass bone scaffolds.

2012: 10 Projects

No.	Project
1	Build a Robot and Develop the Controls and Coding to Guide the Robot (LMD)
2	Select a Sensor and Calibrate it to Automate and Improve the Quality of LMD Work
3	Characterize Dispersants for FEF Project
4	Redesign the Gantry System for the FEF Project
5	Test Conductivity/Develop Procedure Sheets (FEF)
6	Test the Conductivity of Bi-polar Plates from the SLS (LMD) Project and Form the Compression Molding Project
7	Test Existing Bi-Polar Plate for Electricity Production Potential and Design a Better Bi-

	polar Plate Using Bio-inspired Design and Fibonacci Sequence (Fuel Cell Development Regardless of Construction Process)
8	Figure a Way to Reduce Liquid Nitrogen and Bring Cooling Costs Down While Moderating the Temperature in the Compartment for the FEF
9	Characterize the Powders for the FEF Project and Develop a 100% Zirconium Paste
10	Repair and Redesign the LMD Specimen Test Equipment

build a robot and develop the controls an coding to guide it(LMD), select a sensor and calibrate it to automate and improve the quality of LMD work, characterize dispersants for the FEF project, redesign the gantry system for the FEF project, test conductivity/develop procedure sheets (FEF), test the conductivity of bi-polar plates both from the SLS (LMD) project and from the compression molding project, test existing bi-polar plate for electricity production potential and design a better bi-polar plate using bio-inspired design and the Fibonacci sequence (Fuel cell development regardless of construction process), figure out a way to reduce liquid nitrogen and bring cooling costs down while moderating the temperature in the compartment for the FEF, characterize the powders for the FEF project and develop a 100% Zirconium paste, and repair and redesign the LMD specimen test equipment.

2013: 6 Projects

No.	Project
1	Free-form Extrusion Fabrication (FEF)
2	Compliant Mechanism
3	Snake Robot through Additive Manufacturing
4	Water Management of Bi-polo Plates
5	The Effects on Architecture by Bi-active Glass Stamples
6	Sparse-Build Rapid Tooling by Fused Deposition Modeling for Composite Manufacturing and Hydroforming

FEF, Compliant mechanism, Snake robot through additive manufacturing, Water management of bi-polo plates, The affects on architectures by bi-active glass samples, Sparse-Build Rapid Tooling by Fused Deposition Modeling for Composite Manufacturing and Hydroforming,

***Appendix B*:**

Survey Items for Interest in Science

Category	Items	2011	2012	2013	Mean
General Interest	I would like to belong to a science club.	n/a	5.4	5	5.2
	I get bored watching science programs on TV.	n/a	2.5	5.36	3.93
	I would like to be given a science book or a piece of scientific equipment as a present.	n/a	5.9	4.27	5.085
	I dislike reading books about science in my leisure time.	n/a	2.8	4.64	3.72
Mean		**n/a**	**4.15**	**4.8175**	**4.484**
Career Interest	I would dislike being a scientist.	n/a	1.9	5.18	3.54
	I would like to work with people who make discoveries in science.	n/a	6	5.73	5.865
	I would dislike a job in a science laboratory.	n/a	2.5	4.73	3.615
	Working in a science laboratory would be an interesting way to earn a living.	n/a	5.9	4.73	5.315
Mean		**n/a**	**4.075**	**5.0925**	**4.584**
Enjoyment	Science lessons are fun.	n/a	5.9	5.55	5.725
	I dislike science lessons.	n/a	2	5.82	3.91
	School should have more science lessons each week.	n/a	5.5	4.73	5.115
	Science lessons bore me.	n/a	2.3	5.64	3.97
	Science is one of the most interesting school subjects.	n/a	6.1	6	6.05
Mean		**n/a**	**4.36**	**5.548**	**4.954**

Category	Item	2011	2012	2013	Mean
challenges	My mentor gives me tasks that require me to learn new skills.	5.2	5.2	5.64	5.347
	My mentor provides me with challenging assignments.	5	4.9	5.36	5.087
	My mentor assigns me tasks that push me into developing new skills.	5.5	4.9	5.64	5.347
Mean		**5.233**	**5**	**5.547**	**5.26**
friendship	My mentor is someone I can confide in.	5.7	5.9	5.36	5.653
	My mentor provides support and encouragement.	5.8	6	5.73	5.843
	My mentor is someone I can trust.	6	6.1	6.09	6.063
Mean		**5.833**	**6**	**5.727**	**5.853**
role model	My mentor serves as a role-model for me.	5.2	5.5	5	5.233
	My mentor is someone I identify with.	5.5	5.3	5.09	5.297
	My mentor represents who I want to be.	4.7	5.5	4.55	4.917
Mean		**5.133**	**5.433**	**4.88**	**5.149**
acceptance	My mentor accepts me as a competent professional.	5.2	5.2	5	5.133
	My mentor sees as being competent.	5	5.5	4.73	5.077
	My mentor thinks highly of me.	5.4	5.2	4.68	5.093
Mean		**5.2**	**5.3**	**4.803**	**5.101**
satisfaction	My mentor is someone I am satisfied with.	6.3	6	4.36	5.553
	My mentor fails to meet my needs.	6	5.7	5.45	5.717
	My mentor disappoints me (reverse-scored).	6.1	5.8	5.82	5.907
	My mentor has been effective in his/her role.	5.7	6.1	5.64	5.813
Mean		**6.025**	**6.025**	**5.637**	**5.896**

Knowledge:

Items	2011	2012	2013	Mean
I learned a great deal of information about my research area from the project in this workshop.	6	5.5	5.73	5.743
I found this workshop to be very motivational.	5.78	5.4	4.73	5.303
The project we conducted in this workshop was applicable to "real world" engineering.	6.11	5.5	5.82	5.81
Mean	**5.963**	**5.467**	**5.427**	**5.619**

Overall Assessment:

Item	2011	2012	2013	Mean
I have increased my ability to apply knowledge of mathematics, science and engineering through this workshop.	3.9	5.2	5.82	4.973
I have increased my ability to design and conduct experiments, as well as to analyze and interpret data through this workshop.	4.1	5.2	5.82	5.04
I have increased my ability to design a system, component, or process to meet desired research needs through this workshop.	4.2	5.5	5.91	5.203
I have increased my ability to identify, formulate, and solve engineering problems.	3.1	5.3	5.55	4.65
I have increased my ability to understand professional and ethical responsibility.	3.3	5.3	4.91	4.503
I have increased my ability to communicate effectively.	3.78	6	5.55	5.11
This workshop has provided me the broad education necessary to understand the impact of engineering solutions in a global and societal context.	2.33	5.4	4.91	4.213
This workshop has provided me recognition of the need for, and an ability to engage in life-long learning.	3.11	5.6	4.91	4.54
This workshop has provided me knowledge of contemporary issues.	2.33	5.2	4.64	4.057
I have increased an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	3.33	5.5	5.73	4.853
Mean	**3.348**	**5.42**	**5.375**	**4.714**